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# The Impact of Exercising at a Self-Selected Intensity on Concurrent Academic Task Performance

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THE IMPACT OF EXERCISING AT A SELF-SELECTED INTENSITY ON  
CONCURRENT ACADEMIC TASK PERFORMANCE

A Thesis  
Presented to  
The Faculty of the Department of Psychology  
Western Kentucky University  
Bowling Green, KY


In Partial Fulfillment  
Of the Requirements for the Degree  
Master of Arts


By  
Carrie French

May 2018

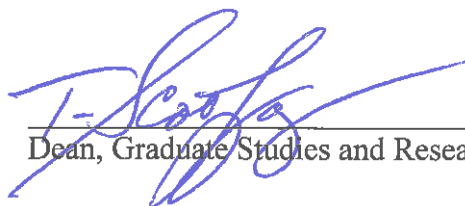
THE IMPACT OF EXERCISING AT A SELF-SELECTED INTENSITY ON  
CONCURRENT ACADEMIC TASK PERFORMANCE

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# THE IMPACT OF EXERCISING AT A SELF-SELECTED INTENSITY ON CONCURRENT ACADEMIC TASK PERFORMANCE

Carrie A. French

May 2018

47 Pages

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The goal of this study was to examine the impact of exercising while completing an academic task on performance on the academic tasks. Participants were 71 undergraduate students at a mid-sized southern university who were asked to complete reading and math tasks while exercising on a stationary bike. Performance on reading and math tasks completed on the stationary bike was compared within-subjects to performance on parallel tasks while seated. Working memory scores were assessed as potential covariates. Order of experimental tasks was evaluated as a between-subjects factor. Within-subjects ANCOVA's indicated that performance on math tasks was significantly worse while exercising. However, no significant differences were found between reading tasks completed while seated and reading tasks completed while exercising. Working memory scores were not significant covariates, and order of experimental tasks was not a significant between-subjects factor. Cognitive load differences were assessed for the different experimental tasks. It is believed that variation in cognitive load during different experimental tasks explains the differences in the reading and math results. The findings of this study indicate that future research should focus on varying the difficulty of the tasks.

## **Introduction**

### **Obesity in the United States**

In recent years, the United States has begun to turn its attention to physical health, and rising obesity rates. The number of Americans who are obese is expected to increase by 65 million by the year 2030 (Wang, McPherson, March, Gortmaker, & Brown, 2011). As a result, preventable diseases associated with obesity are expected to increase healthcare spending by between 48 billion dollars and 66 billion dollars per year in the United States alone by 2030. In 2011, the cost associated with healthcare for diseases related to being overweight, or obese, was 113.9 billion nationally (Tsai, Williamson, & Glick, 2011). At the same time, when asked about barriers to exercise college students, and adolescents, say that time constraints are a significant reason not to exercise (Grubbs, & Carter, 2002; Tappe, Duda, & Ehrnwald, 1989). Classrooms and workplaces have begun to consider and test more active workstations as a potential way to combat obesity in the United States.

### **New Solutions**

Americans describe time constraints as a key reason not to exercise, some have considered multitasking during exercise as a potential solution. Multi-tasking while exercising decreases self-selected exercise intensity (Mauch, French, & Wininger, 2017), but some individuals are choosing not to exercise at all due to time constraints. For individuals not exercising due to perceived time constraints, multitasking offers a potential solution, even if exercise intensity is decreased.

New methods of increasing exercise are being tested in many settings across the United States. However, as classrooms begin to use walking desks or pedal desks, many

ask if exercising while engaging in cognitive tasks in the workplace will decrease cognitive performance. A study of walking desks in the workplace found that using a walking desk did not reduce cognitive performance (Bantoft, Summers, Tranent, Palmer, Cooley, & Pederson, 2016). The study used multiple cognitive assessment methods which included the Wechsler Test of Adult Reading, Digit-Span forward, Digit-Span backward, the Digit Symbol Coding subtest, Letter-Number Sequencing, a Stroop task, and a Choice Reaction Time assessment (Bantoft et al., 2016, p. 145-146). In addition, Gustafson and Cavuoto (2015) found that, although adults rated their physical discomfort higher for using walking desks compared to a regular workstation, their cognitive performance was not decreased. The cognitive tasks assessed in the study by Gustafson and Cavuto (2015) included a test of attention, a matching pairs task, and estimating movement of objects moving across a screen. Schools have a similar question to answer. Will exercising during classroom activities decrease student's academic performance? Individuals considering or engaging in multi-tasking while exercising may wonder if engaging in higher intensity exercise, rather than walking, will impact their performance on cognitive tasks that are completed during exercise.

A review of studies on standing desks in classrooms revealed that standing desks could be useful for increasing the activity level of elementary school students (Minges et al., 2016). However, the review did not include desk settings involving more exercise, such as walking desks or pedal desks. A study by Frost and colleagues (2016) offered some college students the option of using desks that could be voluntarily adjusted to allow standing while working in their college classroom. Participants with desks that could be adapted for standing reported less physical discomfort compared to participants



using regular desks. For all subjects, exam scores did not differ between individuals using different types of desks in the same classroom.

A study by Larson and colleagues (2015) found that walking at 1.5 miles per hour on a treadmill decreased typing performance, but had no impact on the memory of the task later. Overall, the studies that have examined the impact of walking or standing on cognitive performance have not found that walking or standing significantly decrease cognitive performance (Bantoft et al., 2016; Larson et al., 2015). However, those studies were limited to low-intensity exercise (walking) and did not examine specific academic tasks. Higher intensity exercise, such as exercise on a bike, may have a much different impact on cognitive performance (Dietrich, 2009).

Performance on different types of academic tasks, such as reading and math, may be impacted differently by exercise because they require different sets of cognitive skills and resources. To read a passage a person must process new words while maintaining information previously read in awareness to comprehend the passage. Math tasks require a person to focus attention and apply previously learned rules to solve individual problems. At the same time, a person must decide how a previously solved portion of a math problem impacts the next portion of that problem. Additionally, when people complete a reading or math task in a work or school setting, there are typically time limits. For an individual in work settings, the time limit may be a deadline for a project or their daily schedule. For an individual in school, the time limit may be a class period or a deadline for an upcoming project.

Schools need to understand how exercise impacts concurrent performance on specific academic tasks. Previous research has attempted to explain how exercise impacts

performance on reading and math tasks, but has not examined the impact of completing exercise and an academic task concurrently. Tine (2014) found that exercise improved reading performance for low-income adolescents when reading was completed 45 minutes after exercise. Another study found that exercising before reading improved reading performance in elementary aged children (Stewart, Slear, Davis, & Leppo, 2013). Another study attempted to specifically address the impact of exercise on math performance. The study focused on children ages 9-years-old to 12-years-old and found that exercise breaks improved math performance (Howie, Schatz, & Pate, 2015). However, no study has directly addressed how exercising during an academic task, such as reading or math, impacts performance on the academic task.

### **Type of Exercise**

A limited number of exercise modalities are available during which an individual can reasonably engage in a concurrent academic task. Cycling on a stationary bike leaves an individual's hands free for multitasking and is commonly engaged in for more extended periods of time than other forms of cardiovascular exercise such as running. Additionally, many people could easily engage in exercise on a stationary bike in settings such as a classroom. Therefore, a stationary bike is a potentially ideal modality for exercising while multitasking. Exercising at different intensities does not have a significant impact on performance on many cognitive tasks when individuals use a stationary bike (Codish, Becker, & Biggerstaff, 2016). The types of tasks assessed in the study included "Four Cambridge Brain Sciences Inc. computerized tests were completed to assess planning, concentration, short-term memory, and reasoning" (Codish et al., 2016, p. 1). However, research has not examined the impact on academic task

performance. In a classroom setting, workplace setting, or gym, individuals have different fitness levels and will be comfortable exercising at different intensities as a result. Fitness level impacts the intensity of exercise that people self-select and individuals with lower fitness levels select exercise intensities that result in higher  $\text{VO}_2\text{max}$  (Pintar, Robertson, Kriska, Nagle, & Goss, 2006).  $\text{VO}_2\text{max}$  refers to maximal oxygen intake, and is determined by a combination overall activity level and genetic factors. As a result of  $\text{VO}_2\text{max}$  differences individuals of different fitness levels can appear to be exercising at the same intensity but be using different percentages of their available resources for exercise. Therefore, a person with a high fitness level could appear to be engaging in higher intensity exercise compared to someone with a lower fitness level but actually be using fewer of their available resources for exercise. The Queen's College Step-Test (McArdle, Katch, Pechar, Jacobson, & Ruck, 1972) can be used to control for fitness level so that cycling has a similar difficulty level for different individuals. Individuals should self-select exercise intensity while multitasking in the lab because the structure of work and school settings means that individuals will most likely self-select exercise intensity if they are multi-tasking in either setting. Unless a work or school setting employs personal trainers or coaches, there will likely be no one present to provide guidance about ideal exercise intensities. Additionally, some exercise activities will be distracting to others in a work or school setting. Therefore, individuals will be limited in the intensity and type of exercise they are able to take part in while at work or school.

## **Factors that Influence Academic Performance**

Just as fitness level influences self-selected exercise intensity, many different factors affect individual's performance on academic tasks. Some of these factors include: engaging in simultaneous tasks, cognitive ability, and previous academic achievement. Previous research has indicated that multitasking negatively impacts note taking, and exam performance (Waite, Lindberg, Ernst, Bowman, & Levine, 2018). Additionally, having technological distractions nearby while completing an academic task decreases the on-task time for academic tasks (Rosen, Carrier, & Cheever, 2013). Previous research has found that high school achievement was one predictor of college student's grade point averages (Wesley, 1994).

Working memory is a critical component of cognitive ability. Working memory is the amount of information an individual can maintain awareness of while simultaneously processing parts of that information to complete various tasks (Dehn, 2014). Working memory has multiple components, and these components contribute to the completion of multiple types of academic tasks (Dehn, 2014). Academic achievement is an individual's previously acquired knowledge about different academic tasks and is most commonly assessed by grade point average for students at many academic levels (Warden & Myers, 2017). Multiple standardized measures have been devised to measure both academic achievement and working memory.

## **Academic Achievement**

Individuals reading achievement will influence their performance on any reading task they complete while exercising. Reading ability is expected to predict reading task performance because results of reading assessments have been found to predict

performance in various types of coursework (Gray, & Houser, 2006; Leonard & Niebuhr, 1986). An individual's American College Test (ACT; ACT, 2017) Reading Subtest Score can be used to assess reading achievement. Questions on the ACT Reading subtest are designed to assess understanding of key ideas in passages, the structure of what is read, and ability to combine knowledge with ideas (ACT, 2017). While the ACT is designed to assess reading skills in preparation for college other assessments focus on different aspects of reading. Other assessments of reading achievement measure different aspects of reading. The Nelson-Denny is designed to measure reading rate, reading comprehension, and vocabulary (Murray-Ward, 1993). The Woodcock-Johnson Achievement Test, Fourth Edition (WJ-IV; Villareal, 2015) measures word-identification skills, reading fluency, and comprehension.

Individual's math achievement will influence their performance on the math tasks they complete during the study. Math achievement can be defined as prior knowledge of mathematical concepts and score on a standardized test of achievement. Participants will be asked their ACT Math Subtest Score to assess math achievement. ACT scores have been established as valid predictors of academic achievement, and college grades (Schmitt, et al., 2009). The ACT Math Subtest assesses math skills associated with college preparation which include understanding quantities, algebra, functions, geometry, statistics, essential math skills, and word problems (ACT, 2017). The Woodcock-Johnson Test of Achievement, Fourth Edition (Villareal, 2015) is also used to assess math achievement and includes assessments of basic math, geometry, trigonometry, solving logarithm, calculus, math fluency, and word problems. ACT Reading and Math scores represent assessments required for most college students. The WJ-IV requires specialized

training to administer and is a diagnostic measure for learning disabilities. The Nelson-Denny only assesses reading. Therefore, ACT subtest scores are ideal for predicting academic performance for college students.

### **Working Memory**

Working memory is the ability to hold and manipulate information in immediate awareness for use in many types of mental tasks. Working memory is critical for completing basic reading processes, and reading fluently (Dehn, 2014). A key basic reading process is the decoding of words. Decoding words requires processing phonemes and simultaneously holding phonemes in awareness. Reading fluency refers to the automaticity of recognizing words, syllables, and phonemes (Dehn, 2014). Working memory capacity determines the number of phonemes that can be processed before they are automatically recognized. Working memory capacity also determines the number and speed at which phonemes can be processed simultaneously before automaticity is achieved. (Dehn, 2014). Basic reading skills require the following components of working memory phonological and visual-spatial short-term memory, verbal working memory, and executive working memory. The components of working memory used in reading comprehension include verbal and executive working memory (Dehn, 2014). Research has established that working memory and reading comprehension are related, confirmatory factor analysis by McVay and Kane (2012) found that a statistically significant positive correlation exists between measures of working memory and reading comprehension.

Research has further established that working memory is related to math performance. A correlation of .45 was found between a span task, and performance on

math tests (Dehn, 2014; Hutton & Towse, 2001), also a .54 correlation was established between working memory and math problem solving (Dehn, 2014; Swanson & Beebe-Frankenburger, 2004). The correlations between working memory and math performance can be explained because completing math problems requires the use of multiple components of working memory. Numbers and mathematical signs must be processed while mathematical concepts are held in awareness and applied to solve problems. Individuals use different components of working memory when solving math problems which include phonological short-term memory, verbal working memory, visual-spatial working memory, and executive working memory (Dehn, 2014). The types of working memory vary based on individual's age, and math skill level (Dehn, 2014).

Exercise is expected to have different impacts for individuals with different Operation Span (OSPAN) and Reading Span (RSPAN) scores. OSPAN is an assessment of the maximum number of items a person can hold in awareness while simultaneously completing math problems. RSPAN is an assessment of the maximum number of items a person can hold in awareness while simultaneously reading and comprehending sentences. Sibley and Beilock (2007) found that exercise had a positive impact on working memory performance for individuals with the lowest OSPAN and RSPAN scores. Based on the research it is believed that exercise produces the most benefits for individuals with fewer working memory resources. Exercise is therefore expected to have a positive impact on academic performance for individuals with lower scores on RSPAN and OSPAN assessments. Based only on Sibley and Beilock (2007) exercise would not be expected to impact academic performance for individuals with moderate, or high working memory assessment scores. However, the study asked individuals to complete

tasks before and after exercise, not during exercise. It is anticipated that completing tasks during exercise will produce different results due to cognitive load (Artino, 2008).

### **Cognitive Load**

The amount of information being processed in working memory is referred to as cognitive load (Artino, 2008). Germane cognitive load refers to the information being processed in working memory that is relevant to the current task. Extraneous cognitive load is additional cognitive load, or additional information being processed that is not relevant to the current task. Exercising represents a source of extraneous cognitive load. Therefore, exercising while completing an academic task will increase extraneous cognitive load compared to completing an academic task while seated. As a result, individuals being asked to multitask should be asked about cognitive load to assess differences in overall cognitive load. The Mental Effort Rating Scale (Paas, 1992) can be used to assess perceived cognitive load. In addition, to increasing cognitive load, exercise taxes self-control resources and influences allocation of the brain's metabolic resources.

### **Depleted Resources**

Individuals have limited resources to allocate for self-control (Baumeister, Vohs, & Tice, 2007, however, see Hagger et al., 2016). The Strength Model of Self-Control indicates that, as individuals perform tasks which require self-control, these resources become depleted. Individual factors, including motivation influence the impact of depletion (Baumeister et al., 2007). However, when individuals are asked to perform one task which requires self-control, they are less successful when completing a second task which requires self-control within a short time frame (Baumeister et al., 2007). Individuals required to eat chocolate (no self-control) performed as well on a second



frustrating task as participants who completed no first task. Participants required to exercise self-control by eating an unappetizing food performed significantly worse on a second frustrating task (Baumeister et al., 2007). Muraven and Slessareva (2003) found that when participants completed a task that depleted self-control resources, being given information that increased motivation improved performance on tasks even after self-control resources were depleted. It is hypothesized that motivation impacts depletion because individuals can use motivation to substitute for self-control when self-control resources are depleted (Muraven, & Slessareva, 2003). Tasks requiring self-control deplete blood glucose levels (Baumeister et al., 2007). Gailliot and colleagues (2007) found that drinking lemonade, which increased blood glucose, eliminated some of the negative impact of reduced self-control resources.

Exercising and academic tasks both require self-control resources. Additionally, exercise and self-control resources both use blood glucose (Adams, 2013; Gailliot et al., 2007). The Strength Model of Self-Control (Baumeister et al., 2007) indicates that individuals will perform worse on both tasks when asked to complete exercise and academic tasks concurrently because of the strain on limited self-control resources. However, cognitive load associated with different types of tasks (Artino, 2008), working memory (Wechsler, 2008b), and fitness level (Wang et al., 2011) varies from person to person. This indicates the impact of completing an academic task during exercise will vary from person to person.

Exercise requires a variety of neurological processes to take place, and requires the brain to allocate metabolic resources during exercise and following exercise. (Dietrich, 2009). According to Dietrich's Transient Hypofrontality Theory, allocating

metabolic resources to the motor cortex means that the brain's metabolic resources are reduced for other areas of the brain during exercise. Metabolic resources to the cerebral cortex and prefrontal cortex are some of the first reduced when more resources must be allocated to the motor cortex. The cerebral cortex is responsible for perception, cognition, and control of movement (Carlson, 2014). The prefrontal cortex is responsible for regulating awareness of the present, and tasks that need to be accomplished. The motor cortex is responsible for regulating all movements of skeletal muscles (Carlson, 2014). As a result of the reduction of metabolic resources performance on other tasks that require awareness of one's surroundings or attention should be reduced by exercise.

Resource reduction has been measured in animals through multiple types of neuroimaging techniques, and local cerebral glucose utilization (Dietrich, 2009). Reduction of resources allocated to the prefrontal cortex limits awareness of surroundings, reduces attention, and problem-solving functions (Dietrich, 2009). Neuroimaging that confirms resource reduction in animals has not been fully replicated in humans during exercise because neuroimaging involves apparatuses that limit movement of the head, but the data that have been found for humans parallel those from the animal literature (Dietrich, 2009). A direct link has not been established between reduction of metabolic resources, and other psychophysiological response, but EEG activity during exercise has been correlated with rate of perceived exertion (Dietrich, 2009). Rate of perceived exertion assesses how much physical effort a person perceives themselves as putting into a task (Borg, 1998). Dietrich's Transient Hypofrontality theory indicates that individual's performance on an academic task completed during exercise will be reduced due to the brain's limited metabolic resources being allocated to the motor cortexes. It is

believed that increased difficulty of physical exercise, and any other task, will account for the greatest changes in performance. Fitness level contributes to how much a person can reduce resources to other areas of their brain through continued exercise (Dietrich, 2009).

### **The Present Study**

The present study examined whether or not self-selected exercise intensity (m.p.h.) impacts performance on a concurrent academic task. Performance on both reading and math tasks were assessed. The reading task required participants to read passages from a standardized reading assessment, then answer brief questions to assess comprehension after reading. The math task required participants to complete randomized addition, subtraction, multiplication, and division problems. Performance on the academic task completed concurrently with exercise was compared within-subjects to performance on a parallel reading and math task completed while seated at a desk.

An Automated OSPAN task (Unsworth, 2005) and an Automated RSPAN task were used to assess working memory (Friedman & Miyake, 2004). Working memory was assessed as a covariate. A cognitive load assessment was used to measure participant-reported subjective differences in cognitive load across conditions (Paas, Tuovinen, Tabbers, & Van Gerven, 2003). The Queen's College Step-Test (McArdle, Katch, Pechar, Jacobson, & Ruck, 1972) was used to control for fitness level.

Exercising on a stationary bike is the most feasible for completing a concurrent academic task. Participants were asked to cycle on a stationary bike while completing reading and math tasks. Participants were asked to complete reading or math tasks during two separate exercise bouts.

## Hypotheses

- 1.) Participants were expected to complete significantly fewer math problems while exercising compared to while seated. Decreased performance was expected due to increased extraneous cognitive load, taxed self-control resources, and reduced metabolic resources to the parts of the brain completing the academic tasks (Artino, 2008; Baumeister et al., 2007; Dietrich, 2009). Performance differences were expected to covary significantly with ACT Math score and OSPAN score (ACT Inc., 2017; Schmidt et al., 2009; Sibley, & Beilock, 2007).
- 2.) Participants were expected to answer significantly fewer reading comprehension questions correctly after reading while exercising compared to while seated. Performance differences while exercising were expected to be due to use of cognitive resources for exercise (Artino, 2008; Baumeister et al., 2007; Dietrich, 2009). Performance differences were expected to covary significantly with ACT Reading score (ACT Inc., 2017), and RSPAN score (McVay & Kane, 2012; Schmidt et al., 2009).
- 3.) Participants were expected to read significantly fewer words total while exercising compared to while seated. Exercise required cognitive resources and changed the allocation of cognitive resources which were expected to result in decreased academic task performance (Artino, 2008; Baumeister et al., 2007; Dietrich, 2009). Performance differences were expected to covary significantly with ACT Reading Score (ACT Inc., 2018) and RSPAN score (McVay & Kane, 2012; Schmidt et al., 2009).

## **Method**

### **Participants**

Participants were 71 college students recruited from introductory psychology courses utilizing the Psychology Department's Study Board. Participants included 47 females, and 24 males. In addition to Study Board credit participants were awarded a five-dollar payment after completing the final session of the study.

Participants were asked to attend two separate lab visits occurring exactly one week apart. During the first lab visit, participants were asked to complete the American College of Sports Medicine (ACSM) screening form, a diet and hydration survey, and demographic questions. Participants were asked to complete approximately 30 minutes of working memory assessment activities and a three-minute step during the initial visit. During the second lab visit, participants were asked complete two bouts of exercise, and complete two additional activities during rest periods between exercise bouts. The exercise included two 10-minute cycle bouts on the bike. The two lab visits lasted one hour each.

### **Materials**

**Reading passages.** Reading passages were selected from the Nelson-Denny Reading Test (Brown, Fishco, & Hanna, 1993). The Nelson-Denny is a standardized assessment of reading comprehension, vocabulary, and fluency. Each version of the assessment has seven passages. The passages range in difficulty from fifth-grade reading level to college senior reading level. The passages have a mean reading level of tenth grade. Passages ranging from one page to one paragraph in length will be utilized for the study. The reading passages were reordered, so that passage sets had similar orders of difficulty. The sets of passages were converted to a PDF file that participants could read

through themselves during the study. The documents with passages were placed on a Windows Surface Pro 4. Two additional reading passages from an ACT preparation website were added because some participants were able to complete seven passages in the allotted time frame (ACT, 2017).

**Reading questions.** After being assigned to read, participants were asked to answer two questions about each passage they read while seated or while exercising. The questions were multiple choice and selected from the Nelson-Denny Reading Test (Brown et al., 1993). Two questions were also selected from each passage from the ACT preparation website (ACT, 2017). For each of the nine total passages participants were asked questions about the overall content of the passage. Questions that reflected overall content were selected from the questions available by two graduate students with previous training in assessments. Participants were not asked questions about passages they did not finish reading. Participants were not permitted to view the passages while answering the questions. The sets of questions were placed on separate Qualtrics surveys. Links to the Qualtrics surveys were placed on a Windows Surface Pro 4. Number of reading questions answered correctly was used as the variable for reading comprehension. Participants could only complete questions from passages they read, and only received credit for information that was attended to, and remembered, from each reading activity. Each question had four possible answers. Possible scores on the assessment ranged from “0” to “18.”

**Math problems.** The math problems used in the study were selected from a list of 400 problems already created in the lab where the study took place. The problems were all used in previous studies where participants were asked to complete them while

exercising. Participants were asked to complete the math problems either while exercising or while seated. When participants were asked to complete math problems while exercising, a researcher controlled a PowerPoint containing the math problems. Participants were directed to say the correct answer to each math problem aloud before moving on to the next math problem. Participants completed the math problems until the end of the exercise bout, regardless of the number of problems they were able to complete.

When participants were asked to complete math problems while resting, they also completed the math problems on a PowerPoint displayed on a Windows Surface Pro 4. Participants only moved onto the next math problem after answering the current problem correctly. Therefore, participants only received credit for the number of problems answered correctly. Participants were only asked to complete addition and subtraction problems due to observations from a previous study (Mauch et al., 2017) indicating that most college students can complete addition and subtraction problems rapidly. However, many college students could not complete multiplication and division problems at an equivalent rate (Mauch et al., 2017).

**Working memory measures.** An automated Reading Span test (RSPAN) was used to assess working memory (Friedman & Miyake, 2004). The Automated Operation Span Task (OSPAN) (Unsworth, 2005) was also used to assess working memory. The RSPAN and OSPAN tasks assess working memory using similar but different tests. The RSPAN task emphasizes reading, while the OSPAN task emphasizes completing math problems. The tasks have a correlation of .67 for males, and .68 for females (Redick, et al., 2012).

***Working memory-RSPAN.*** An automated Reading Span test was used to assess working memory (Conway, Kane, Bunting, Hambrick, Wilhelm, & Engle, 2005). The task involves a pretest where participants are asked to practice memorizing a sequence of numbers presented on the screen. Participants receive feedback for their performance during the pretest phase. Following the pretest, participants are asked to answer questions about whether a sentence presented on the screen makes sense. Before each sentence, participants are presented with a single letter. After answering questions about a set of sentences, participants are asked to recall all the letters presented before each sentence in the passage. The number of sentences in a set changes based on a participants' performance in the test. Participants must correctly judge the content of sentences for the letters recalled to receive credit. Several studies have supported the internal consistency reliability and the test-retest reliability for the task (Conway et al., 2005). They also report criterion validity for the task is supported based on the prediction of performance on attention and perception tasks. The task has a test-retest reliability of .76 (Redick et al., 2012).

***Working memory-OSPAN.*** Participants completed an automated version of an operation span task (Unsworth, 2005). The operation span task required participants to solve a math problem. Participants were asked whether the answer to the problem was true or false. After solving the problem participants were given a single letter to remember. Participants were asked to recall all the letters after solving a series of math problems. The automated operation span task correlates with other measures of working memory (Unsworth, 2005) and has a test-retest reliability of .83.



**RPE.** Rate of perceived exertion was assessed four times for participants during the study. The first time, participants were asked to review the measure while seated to obtain a baseline measure. Participants were also asked rate of perceived exertion at the conclusion of a step-test, and near the end of each exercise bout. Rate of perceived exertion was assessed using Borg's CR10 scale (Borg, 1998). Originally, the scale had points from 6 to 20, which was intended to be the equivalent of heart rates 60 to 200. However, participants had difficulty with the range of the scale during previous studies. The CR10 scale has points ranging from 0 to 10. A "0" corresponds to no exertion, and a "10" on the scale indicates an extremely strong or nearly maximal level of exertion. Reliability estimates for the CR10 scale are similar to the original scale, and most reliability coefficients for both scales are greater than .90. Multiple studies have supported the construct validity of the CR 10 scale (Borg, 1998).

**Cognitive load.** Participants perceived cognitive load was assessed with a mental effort rating scale. The scale was designed to assess the amount of mental effort utilized for a task (Paas, 1992). Participants are asked to rate mental effort on a scale of 1 to 9. The lowest point on the scale is "very, very low mental effort" which corresponds to a "1". The highest point on the scale is "very, very high mental effort" this corresponds to a "9". Evidence of the predictive validity of the scale was found based on correlations with errors on different types of tasks (Ayers, 2006). Construct validity for the scale is supported by differences in ratings for low complexity tasks compared to high complexity tasks (Paas, Van Merriënboer, & Adams, 1993). In addition, a coefficient alpha value of .90 for the scale was found for estimates across multiple types of problems.

**3-minute step test.** The Queens College Step Test (McArdle, Katch, Pechar, Jacobson, & Ruck, 1972), was used to assess cardiovascular fitness. Participants stepped on a 16.25-inch step to a metronome at a rate of 22 steps per minute (88 bpm; females) or 24 steps per minute (96 bpm; males). Participants stepped for three minutes' total. Participants were asked to utilize the same leg to step-up during the first 90 seconds of the step test. Participants were instructed to switch leading legs, at 90 seconds. RPE and heartrate were recorded at the end of the step test. Test-retest reliability for the step test is  $r=.92$  (McArdle et al., 1972). Heart rate recovery has a relationship of  $r=-.75$ , with a maximal  $\text{VO}_{2\text{max}}$  test (McArdle et al., 1972). The results of the test were used to determine the resistance on the bike during exercise bouts. The purpose of standardizing resistance on the bike was to ensure exercise intensity is equivalent across participants regardless of fitness level.

**Exercise equipment.** A matrix U5x upright stationary bike was used for the cycling bouts. Participants wore a Polar heart rate monitor during the lab visits. A set of aerobic platforms was used for the step-test at a height of 16.25 inches.

**Tablet set-up.** During exercise bouts, the tablet was mounted on a clipboard to the stationary bike. The tablet was mounted so that it did not obstruct the participant or research assistants' view of the bike's display. A wire mesh basket and a cushion were used to hold the tablet in the same position for every participant. During the seated tasks the participants used a similar tablet which was placed on a desk.

## **Procedure**

**First session.** During the first session, participants were screened for participation. After entering the lab, participants were asked to verbally confirm they had

consumed enough food and drink to participate in physical activity. Participants were then screened using the American College of Sports Medicine (ACSM) risk stratification form. Only participants meeting criteria for “Low Risk” were permitted to participate. After completing the ACSM form, participants were asked to verify their food and drink consumption in the last three hours and the last 24-hours via an online survey. The researcher watched participants complete the survey to verify food and drink consumptions. Participants that consumed too little food in the last 24-hours or participants in danger of dehydration were not allowed to participate. However, those participants were able to reschedule their participation for in study for a later date. Participants that did not meet the ACSM guidelines for “low risk” were disqualified from the study.

After completing the initial screening measures, participants were asked to complete the informed consent for the study. Following completion of the informed consent, participants were asked to complete the OSPAN task via Inquisit software on a Windows Surface Pro 4. The task took participants approximately 15 minutes.

Next participants were asked to complete demographic questions. The LTEQ, a height and weight assessment, and math performance anxiety questions were included with the demographic questions. Participants were asked to put on an armband heart-rate monitor prior to completing the demographic questions. They wore the heart rate monitor for the remainder of the lab visit and all of session two.

The heartrate monitor was used to collect baseline heartrate data and heartrate information after the 3-minute-step test. Next, participants were asked to complete demographic questions and the math anxiety scale. After completing the demographic

scale, participants were asked to read over the RPE scale instructions. The researcher collected baseline heartrate while participants are seated and reading. Participants were asked to provide an RPE reading for sitting and to answer demographic questions. Next, participants were given the cognitive load measure. Participants were asked to rate their cognitive load only for answering demographic questions.

After completing the RPE and cognitive load measure, participants were asked to complete an automated RSPAN test. The test took approximately 15 minutes for most participants. After completing the RSPAN task, participants completed a 3-minute step test. The step-test was used to estimate their  $VO_{2max}$  for the second session. At the end of the first session, participants were granted the first portion of their study board credit.

**Second session.** During the second session, participants were asked to complete two 10-minute exercise bouts, while completing concurrent academic tasks. Participants were asked to complete reading and math activities while seated, in addition to completing the exercise bouts. Participants were randomly assigned to reading or math first. During the exercise bouts, HR and RPE were assessed towards the end of each exercise bout after nine minutes, of each 10-minute exercise bout. Participants were asked to rate their cognitive load immediately after completing each exercise bout. Participants also completed another diet and hydration survey. Individuals in danger of malnutrition or dehydration were not be allowed to participate.

The following table illustrates the order of tasks during part two of the study.

Table 1

*Order of Tasks by Condition*

	<u>Condition A</u>	<u>Condition B</u>	<u>Condition C</u>	<u>Condition D</u>
1	Diet and Hydration & HR Monitor	Diet and Hydration & HR Monitor	Diet and Hydration & HR Monitor	Diet and Hydration & HR Monitor
2	Math Seated	Reading Exercise	Reading Seated	Math Exercise
3	Math Exercise	Reading Comprehension Questions	Reading Comprehension Questions	Break
4	Break	Break	Reading Exercise	Math Seated
5	Reading Seated	Reading Seated	Reading Comprehension Questions	Reading Exercise
6	Reading Comprehension Questions	Reading Comprehension Questions	Break	Reading Comprehension Questions
7	Reading Exercise	Math Exercise	Math Seated	Break
8	Reading Comprehension Questions	Break	Math Exercise	Reading Seated
9	Payment and Credit	Math Seated	Payment and Credit	Reading Comprehension Questions
10	Debriefing	Payment and Credit	Debriefing	Payment Credit
11		Debriefing		Debriefing

**Condition A.** Participants in Condition A spent nine minutes completing math problems while seated as the first academic task. Participants had nine minutes to answer as many problems correctly as possible. Next participants were asked to complete a 10-minute exercise bout on a stationary bike while completing a parallel set of math problems. Participants were offered a two-minute water break. After the first 10-minute exercise bout participants were asked to complete reading passages while seated for nine minutes. After nine minutes of reading, participants completed reading questions based on the passages they finished reading. Next, participants completed the second ten-minute exercise bout. Participants were asked to read passages while exercising. After exercise participants were asked to answer questions based on the passages they finished reading.

**Condition B.** Participants in Condition B were assigned to complete reading tasks while exercising first. First, participants were asked to spend ten minutes reading while exercising on a stationary bike, then answer reading comprehension questions about what was read. Participants were offered a two-minute water break after the exercise bout. Participants were then asked to spend nine minutes reading a parallel set of passages while seated then answer reading comprehension questions. Next participants were asked to complete math problems while completing a ten-minute bike bout. After a two-minute break participants were asked to complete a parallel set of math problems for nine minutes while seated.

**Condition C.** Participants in Condition C were assigned to complete reading tasks first. Participants were asked to read while seated for nine minutes then answer reading comprehension questions. Participants were then asked to complete the first ten-minute

exercise bout while reading passages. Participants were asked to answer questions about the reading questions they answered after they complete the exercise bout. Next participants were offered a two-minute water break. Participants were then asked to complete math questions while seated for nine-minutes. Finally, participants were asked to complete the last ten-minute exercise bout while answering math questions.

***Condition D.*** Participants in Condition D were assigned to complete a math task while exercising first. Participants were offered a two-minute water break after the exercise bout. Next participants were asked to spend nine minutes completing math problems while seated. Next participants were asked to read parallel passages for nine-minutes while seated. Participants were then asked to complete another ten-minute exercise bout while reading passages, followed by comprehension questions. After a two-minute water break, participants were asked to spend nine-minutes reading passages while seated then answer comprehension questions.

### **Session Two Instructions**

Before starting the time for the reading seated task participants were given the following instructions; “You are being asked to read these passages. Read as quickly as you can while paying attention to content.” Before starting the math seated task participants were given the following instructions, “You are being asked to complete these math problems, answer as quickly and accurately as you can.” Before the reading during exercise task participants were given the following instructions, “You are being asked to complete ten minutes on the bike. You are free to pedal as fast or slow as you wish but please do not change the resistance. At the same time, you are being asked to read these passages, read as quickly as you can while paying attention to content.” Before

the math and exercise task participants were given the following instructions, “You are being asked to complete ten minutes on the bike, pedal as fast or slow as you wish but please don’t change the resistance. At the same time, you are being asked to complete these math problems. Answer as quickly and accurately as you can.”

**All Conditions.** Participants were provided payment, debriefed on the study, and granted study board credit following completion of the last exercise bout. Regardless of the assigned condition, heartrate data, RPE, and cognitive load were collected for all participants during both exercise bouts. When participants completed each ten-minute bout of exercise, heartrate data, and RPE were collected at nine minutes. At the end of each exercise bout, participants were asked about cognitive load.

Participants were asked to complete reading or math activities for nine minute to make the time length similar to exercise bouts. At the nine minute mark the researcher interrupted the participant’s academic task to assess RPE during the exercise bout. During the exercise bout, the researcher recorded the number of math problems or reading passages completed by the participant at nine minutes. The research also recorded the total number of words read. Participants were only asked questions about reading passages completed before nine minutes of exercise were completed. The researcher also collected information about the number of total reading passages completed, or math problems completed for the entire exercise bout.

Data for math problems and reading passages were collected for analysis at nine minutes during exercise to standardize the time available for completing the activities across participants. Participants were temporarily distracted from the activity when the researcher asked them about RPE towards the end of the exercise bout, and not as likely



to be as efficient completing the activity, in the final minute of exercise for the time condition as a result. The four conditions were used because they accounted for all possible orders of the academic and exercise tasks, without requiring any participant to complete exercise bouts back-to-back. Participants were asked to complete tasks in different orders because the order of tasks was predicted to influence variations in academic task performance.

## Results

### Preliminary Analysis

Descriptive statistics for academic tasks, and condition were assessed as part of the preliminary analysis.

**Math fluency.** The following table shows the mean and standard deviation of math problems answered correctly by condition.

Table 2		
<i>Mean Number of Math Problems Completed by Condition</i>		
<u>Condition</u>	<u>Sitting</u>	<u>Biking</u>
A	101.4 (46.0)	83.7 (28.6)
B	91.0 (39.4)	65.6 (29.6)
C	92.4 (45.4)	76.0 (38.7)
D	93.5 (40.6)	70.4 (31.9)
Overall	94.7 (42.3)	74.1 (32.5)

The overall totals represent the mean number of math problems completed across all four conditions. Individuals completed fewer math problems while cycling compared to while seated.

**Reading comprehension.** The following table represents the mean and standard deviation of reading comprehension questions answered correctly by condition.

Table 3		
<i>Mean Reading Comprehension Score by Condition</i>		
<u>Condition</u>	<u>Sitting</u>	<u>Biking</u>
A	5.72 (2.5)	7.06 (2.9)
B	5.20 (2.3)	6.07 (2.7)
C	5.22 (2.3)	6.61 (2.5)
D	5.47 (3.5)	6.68 (2.5)
Overall	5.41 (2.7)	6.63 (2.6)

The overall totals represent the mean number of reading comprehension questions answered correctly by condition. The means displayed above indicate participants typically answered fewer reading comprehension correctly while seated compared to while biking.

**Reading fluency.** The following table represents the mean and standard deviation of words read while seated and while exercising.

Table 4		
<i>Mean Words Read by Condition</i>		
Condition	Sitting	Biking
A	1784.1 (557.4)	1866.1 (523.9)
B	1660.6 (340.2)	1627.3 (400.9)
C	1746.8 (575.4)	1764.4 (483.3)
D	1672.6 (574.4)	1671.5 (511.4)
Overall	1716.9 (517.8)	1734.5 (483.2)

Overall totals represent the mean number of words read across conditions. The means displayed above indicate participants read slightly fewer words while seated overall.

**Condition.** Condition was assessed as a between subjects-factor for math fluency, reading comprehension, and reading fluency. Condition was not a significant between-subjects factor for reading fluency  $F(3, 71) = .896, p=.448$ . Condition was not a significant between-subjects factor for reading comprehension  $F(3, 71) = .170, p=.916$ . Condition was not a significant between-subjects factor for reading fluency  $F(3, 71) = .353, p=.787$ .

### **Hypothesis 1: Math Fluency**

Participants were expected to complete significantly fewer math problems while exercising compared to while seated. ACT Math Score and OSPAN were expected to be significant covariates. Performance differences were assessed with a within-subjects

ANCOVA. ACT Math score and OSPAN score were assessed as significant covariates in the analysis.

A within-subjects ANCOVA revealed that math performance was better while sitting ( $M=94.7$ ) when compared with math performance while exercising ( $M=74.1$ );  $F(1, 71) = 27.4, p < .001, \eta^2_p = .294$ . OSPAN was not a significant covariate  $F(1, 71) = .866, p = .355$ . Not enough participants reported ACT math score during the study for the score to be assessed as a potential significant covariate.

### **Hypothesis 2: Reading Comprehension**

Participants were expected to answer significantly fewer reading comprehension questions correctly after reading while exercising compared to reading while seated. ACT Reading Score, and RSPAN were expected to be significant covariates. Performance differences were assessed with a within-subjects ANCOVA.

A within-subjects ANCOVA revealed that differences between reading while seated ( $M=5.41$ ) and reading while exercising ( $M=6.63$ ) were not significant  $F(1, 71) = 1.734, p = .191$ . RSPAN was not a significant covariate  $F(1, 71) = .641, p = .426$ . Condition was not a significant between-subjects factor  $F(3, 71) = .170, p = .916$ . The number of participants reporting ACT Reading score was insufficient for ACT Reading score to be assessed as a potential significant covariate.

### **Hypothesis 3: Reading Fluency**

Participants were expected to read significantly fewer words total while exercising, compared to while seated. Performance differences were expected to covary significantly with ACT Reading Score, and RSPAN score. Performance differences were

assessed with a within-subjects ANCOVA, ACT Reading Score, and RSPAN score were assessed as covariates.

A within-subjects ANCOVA revealed that differences in the number of words read between reading while seated ( $M=1716.99$ ) and reading while exercising ( $M=1734.45$ ) were not significant  $F(1, 71) = .109, p=.743$ . RSPAN was not a significant covariate  $F(1, 71) = .330, p=.568$ . The number of participants reporting ACT Reading score was insufficient for ACT Reading score to be assessed as a potential significant covariate.

### **Cognitive Load**

The following table shows the mean cognitive load by task type.

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Table 5  
*Average Cognitive Load by Task Type*

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<u>Task</u>	
Math Seated	5.27 (1.39)
Math Exercise	5.92 (1.65)
Reading Seated	4.06 (1.70)
Reading Exercise	4.89 (1.65)

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A within-subjects ANOVA was used to assess differences in cognitive load during the experimental tasks. Condition was assessed as a between-subjects factor. Differences in mean cognitive load for all four trials were significant  $F(3, 71) = 21.89, p<.001, \eta^2_p = .503$ . Condition was not a significant between-subjects factor overall  $F(1, 71) = 1.254, p=.264$ .

## **Discussion**

### **Math Fluency**

Individuals answered significantly fewer problems when they were exercising compared to when they were seated. The differences were expected based on Dietrich's Transient Hypofrontality Theory (Dietrich, 2009), cognitive load theory (Artino, 2008), and The Strength Model of Self-Control (Baumeister et al., 2007). Rapidly completing math problems requires individuals to make quick decisions about information, and use multiple components of working memory (Dehn, 2012). OSPAN was not a significant covariate for math fluency, which indicated the need to examine other potential covariates. It is unknown if ACT Math score was a significant covariate with math fluency. As completing math problems requires applying previously learned mathematical concepts, and the ACT Math subtest was designed to assess previously learned knowledge in math it is likely that the score would have explained some of the variance (ACT, 2017).

Answering math problems requires making decisions about information. Participants in this study completed fewer problems correctly during exercise, a finding which supports the Transient Hypofrontality Theory's (Dietrich, 2009) notion that exercise diverts metabolic resources in the brain and therefore temporarily inhibits neurological processes not directly related to exercise. Overall, the math fluency findings indicate that processes that require decision making are inhibited during exercise.

The significant differences in performance for math fluency were moderate. This finding indicates that schools and workplaces should use caution before having individual's complete math problems, or similar tasks during exercise. Other tasks that

require decision making include answering emails, answering exam questions, or working on any project or assignment involving quantitative skills.

### **Reading Comprehension and Reading Fluency**

Differences in reading fluency and reading comprehension between the seated and exercise tasks were not significant. Overall, this result is inconsistent with what was expected based on previous literature. Individuals improve automaticity in reading tasks over time (Dehn, 2012). Reading can be completed in a more passive manner than completing math problems. These results indicate that individuals can complete tasks that are more automated during exercise compared to tasks which require decision making. Overall, the results indicate that individuals are generally able to read while exercising at a self-selected intensity without a significant impact on reading comprehension or fluency.

However, some aspects of the reading passages and participant characteristics must be taken into account when considering applying the findings. Participants in the study were all enrolled in college, but the reading passages had an average reading level of tenth-grade. In addition, the reality that all of the participants were enrolled in college courses indicates that the majority of participants had obtained a considerable level of reading proficiency. In a school setting, individuals are typically progressing to more challenging materials. Therefore, caution should be used when considering allowing students to read while exercising in a school setting. In general, there will be variation in how difficult individuals find the reading tasks they need to complete. Therefore, employers should use caution when encouraging exercise while completing reading tasks or equivalent tasks in the workplace.

Reading is a task that can be completed passively. Although reading requires attending to content and prioritizing content, it does not require making decisions. Tasks equivalent to reading include watching a video or completing a very familiar task. The results indicate performance would not be inhibited in a work or school setting on tasks that are fairly automatic, and easy for an individual to complete.

### **Cognitive Load**

The cognitive load was assessed during all academic tasks in the study. Significant differences in cognitive load were found between the different tasks. Participants reported significantly higher cognitive load during the math tasks compared to the reading tasks. Cognitive load theory (Artino, 2008) indicates that increases in extraneous cognitive load contribute to decreases in performance on cognitive tasks. The significant differences in cognitive load during the different types of experimental tasks corresponded to differences in performance. Overall, individuals rated math tasks as requiring a higher level of cognitive load compared to reading tasks. Individuals performance on math tasks decreased when they exercised, but similar differences did not occur for reading. Increases in cognitive load represent increases on in the total percentage of a person's working memory resources that are being used during a task (Artino, 2008). This indicates that higher cognitive load during the math tasks, compared to the reading tasks might have contributed to the performance differences.

Participants completed only one type of math and reading task during the study. Although two reading tasks and two reading tasks were completed, they were designed to be similar in difficulty. The significant differences in cognitive load and corresponding differences in performance indicate that math or reading tasks of different difficulty



levels may have produced different results. Easier reading tasks would also be unlikely to correspond to performance differences. However, reading tasks with higher grade levels may have resulted in a significant difference in fluency and comprehension when participants were exercising. During the math tasks, many addition and subtraction problems contained numbers between ten and 100. If the problems only contained numbers 0 to 9, this would have likely decreased participants cognitive load because they would have been required to maintain awareness of smaller amounts of numerical information. Decreasing the difficulty of the math problems would have likely resulted in smaller performance differences when participants were exercising.

### **Limitations of the Current Study**

All participants in the study were college students. Some considerations need to be taken before generalizing the results from the study to the rest of the population. College students all either completed high school or took an equivalency exam prior to entering college. This means that all participants were required to have some knowledge of reading or mathematics. Younger participants or school-aged participants cannot be assumed to have the same level of academic skill, and are generally working towards improving math and reading proficiency. Additionally, individuals in the general population cannot be assumed to have levels of reading or mathematical skill equivalent to that of college students.

Individuals in the study were required to complete prescreening to ensure they were healthy enough to participate. For individuals with health challenges, completing any exercise activity may represent a greater increase in extraneous cognitive load (Artino, 2008). Individuals in the study all reported either engaging in exercise regularly

or considering starting an exercise regimen. If individuals are not interested in beginning an exercise regimen they may not have similar results. Finally, all individuals who participate signed-up for the study knowing that exercise on a stationary bike would be involved. The description of the study may have attracted individuals who were healthier on average and had more positive perceptions of exercise. Individuals who volunteered for the study had many other opportunities available as alternatives for course credit.

The present study only examined reading and math tasks at one overall level of difficulty each. Examining tasks of different difficulty levels within-subjects could have yielded different results. Additionally, participants completed academic tasks for only nine-minutes per tasks. Length of time dedicated to various tasks varies in work and school settings. If individuals completed the tasks for different length of time, the differences in performance may have changed.

Transient Hypofrontality Theory (Dietrich, 2009) indicates that changes in cognitive performance that are expected during exercise are due to changes in metabolic resources allocation in the brain. The present study did not collect physiological data other than heartrate. Heartrate was used in this study to monitor potential participant distress during exercise and not considered as a variable. Physiological data are needed to better understand how physiological changes correspond to changes in cognitive performance.

The results of the current study do not consider previous academic achievement due to lack of data. Information about individuals ACT scores was needed to determine if academic achievement accounts for some variance in the results. ACT score, SAT score,

grade point average, or academic major, all represent potential modalities for understanding academic achievement.

Finally, the present study only examined exercise on a stationary bike. Other types of exercise such as using a treadmill or elliptical may produce different results. It is believed these exercise modalities could produce different results because they require individuals to engage in different patterns of movement during exercise.

### **Implications of the Results**

Overall, the results of the current study indicate that whether or not exercise impacts performance on a concurrent academic task depends on the difficulty of the task, and the type of task. Individuals should use caution before deciding to complete reading tasks or similar tasks while exercising at work or school. The current study indicates that individuals should not complete math tasks or similar tasks that require decision making while exercising.

The results of the current study can also be applied to individuals considering multitasking while exercising. If an individual is interested in exercising while completing academic or similar tasks while exercising the results indicate reading tasks or similar tasks will not be impacted, but tasks equivalent to math will be impacted. Individuals could consider completing some tasks similar to reading while exercising that are not of high difficulty level without fear that their performance on the task will be inhibited. However, previous research indicates their self-selected exercise intensity will decrease significantly due to multitasking (Mauch et al., 2017).

## **Directions for Future Research**

The results of this study produced multiple potential directions for future research. Future research could focus on different types of tasks, participants of different ages, different modalities of exercise, tasks of varying difficulty level, different lengths of time on task, and collecting information on individual's physiological responses during exercise. Finally, future research should consider whether or not individuals with a diagnosis that impacts attention, or learning respond differently to completing academic tasks during exercise differently when compared to other individuals. Diagnoses that can impact learning in specific subject areas and/ or attention include Attention-Deficit/Hyperactivity Disorder (ADHD), and Specific Learning Disorders (SLD) (American Psychiatric Association, 2013). Understanding whether or not individuals with ADHD or SLD are impacted differently by completing exercise, and academic tasks simultaneously will allow schools considering implementing exercise desks to consider if they will impact all students in the same way.

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## APPENDIX A: INFORMED CONSENT

### Informed Consent Form

**Project Title:** Exercise and Cognition  
**Investigators:** Dr. Steven R. Wininger & Carrie French,  
Psychology Department, (270) 745-4421



You are being asked to participate in a project conducted through Western Kentucky University. The University requires that you give your signed agreement to participate in this project.

- **You must be 18 years old or older to participate in this research study.**
- **IF YOU MIGHT BE PREGNANT OR IF YOU ARE TRYING TO CONCEIVE CHILDREN, YOU SHOULD NOT PARTICIPATE IN THE STUDY!**

The investigator will explain to you in detail the purpose of the project, the procedures to be used, and the potential benefits and possible risks of participation. You may ask any questions you have to help you understand the project. A basic explanation of the project is written below. Please read this explanation and discuss with the researcher any questions you may have.

If you then decide to participate in the project, please sign this form in the presence of the person who explained the project to you. You should be given a copy of this form to keep.

1. **Nature and Purpose of the Project:** The purpose of the current study is to examine the interaction between exercise and cognitive tasks.
2. **Explanation of Procedures:** As a volunteer in this research project you will be asked to attend two test sessions. The first session will consist of completing: a) two working memory assessments, b) demographic questions, and c) a three-minute step test. The second session will consist of a) two 10-minute bouts on a stationary bike while reading or doing math problems, and b) reading passages for nine minutes and answering math questions for nine minutes while seated.
3. **Discomfort and Risks:** Potential risks to your health and well-being because of your participation include 1) cardiovascular injury (heart attack or stroke), 2) severe acute fatigue, 3) light headedness, dizziness, nausea, and 4) all other possible risks associated with engaging in low to high intensity exercise.

-The American College of Sport Medicine (2000) suggests the following regarding the potential risk/injury as the result of participating in *maximum intensity testing or testing in which intensity is contingent upon pre-existing health conditions*:

- 1 Risk of Death during or immediately after is less than 0.01% (1 in 10,000)
- 2 Risk of heart attack during or immediately after is less than 0.04% (4 in 10,000)
- 3 Risk of hospitalization as a result of testing is less than 0.2% (2 in 1,000)

- The ACSM goes on to state that the risk associated with **sub-maximal** physical fitness testing appears to be even lower. These statements are made for the general population. We will take

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every precaution to ensure your safety; an individual with CPR certification will perform testing. It is very important that you fully disclose anything that would increase your risk for participating in low to high intensity exercise.

- IF YOU FEEL ILL AT ANY TIME DURING, BEFORE, OR AFTER THIS STUDY LET THE INVESTIGATORS KNOW IMMEDIATELY!

4. **Benefits:** For your participation you may be awarded course credit or extra credit, which may be applied to your psychology course grade with your instructor's approval. Participants who complete both sessions will also be paid \$5. Participants who complete both sessions who are not eligible for study board credit will receive \$20. You understand that there are no other direct benefits to you for participation in this study.

5. **Confidentiality:** Participation in the study will be entirely confidential and kept securely. Names and identifying information will not be associated with publications or presentations resulting from participation in this study.

6. **Refusal/Withdrawal:** Refusal to participate in this study will have no effect on any future services you may be entitled to from the University. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

*You understand also that it is not possible to identify all potential risks in an experimental procedure, and you believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks. If a medical emergency does occur, you understand that you are responsible for any costs incurred, including but not limited to the services of Emergency Medical Technicians, emergency room care, hospitalization, etc. We strongly encourage you to ensure that you have adequate health insurance coverage or other means of satisfying any costs for which you will be liable.*

\_\_\_\_\_  
Signature of Participant

\_\_\_\_\_  
Date

\_\_\_\_\_  
Witness

\_\_\_\_\_  
Date

- I am aware that I will be asked to provide a full description of my food and water intake of the last 24 hours leading up to physical activities involved in the research.

(Initial here) \_\_\_\_\_

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT  
THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY  
THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD

Paul Mooney, Human Protections Administrator  
TELEPHONE: (270) 745-2129



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